Retrievals of peroxyacetyl nitrate (PAN) from CrIS

Vivienne Payne

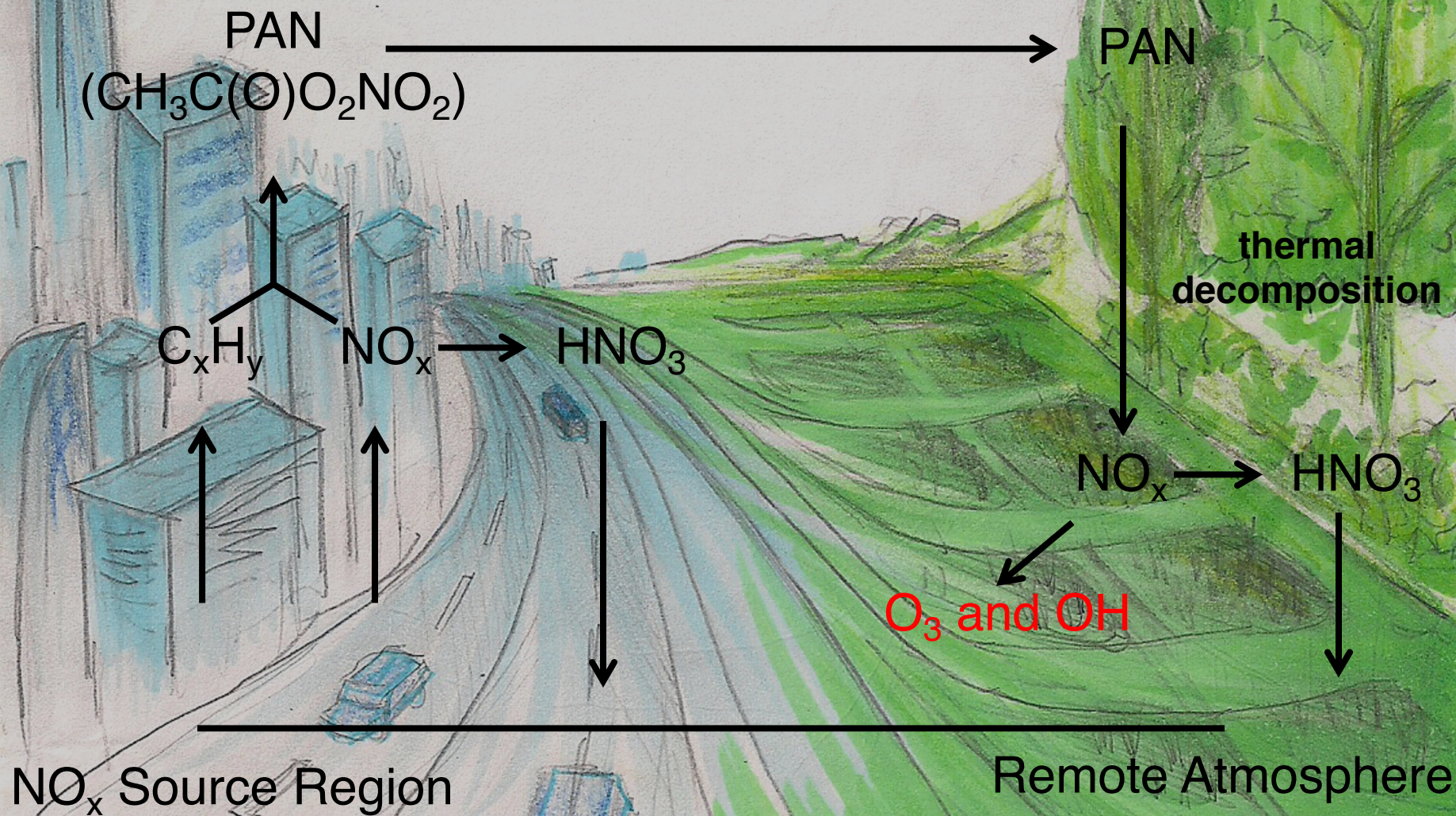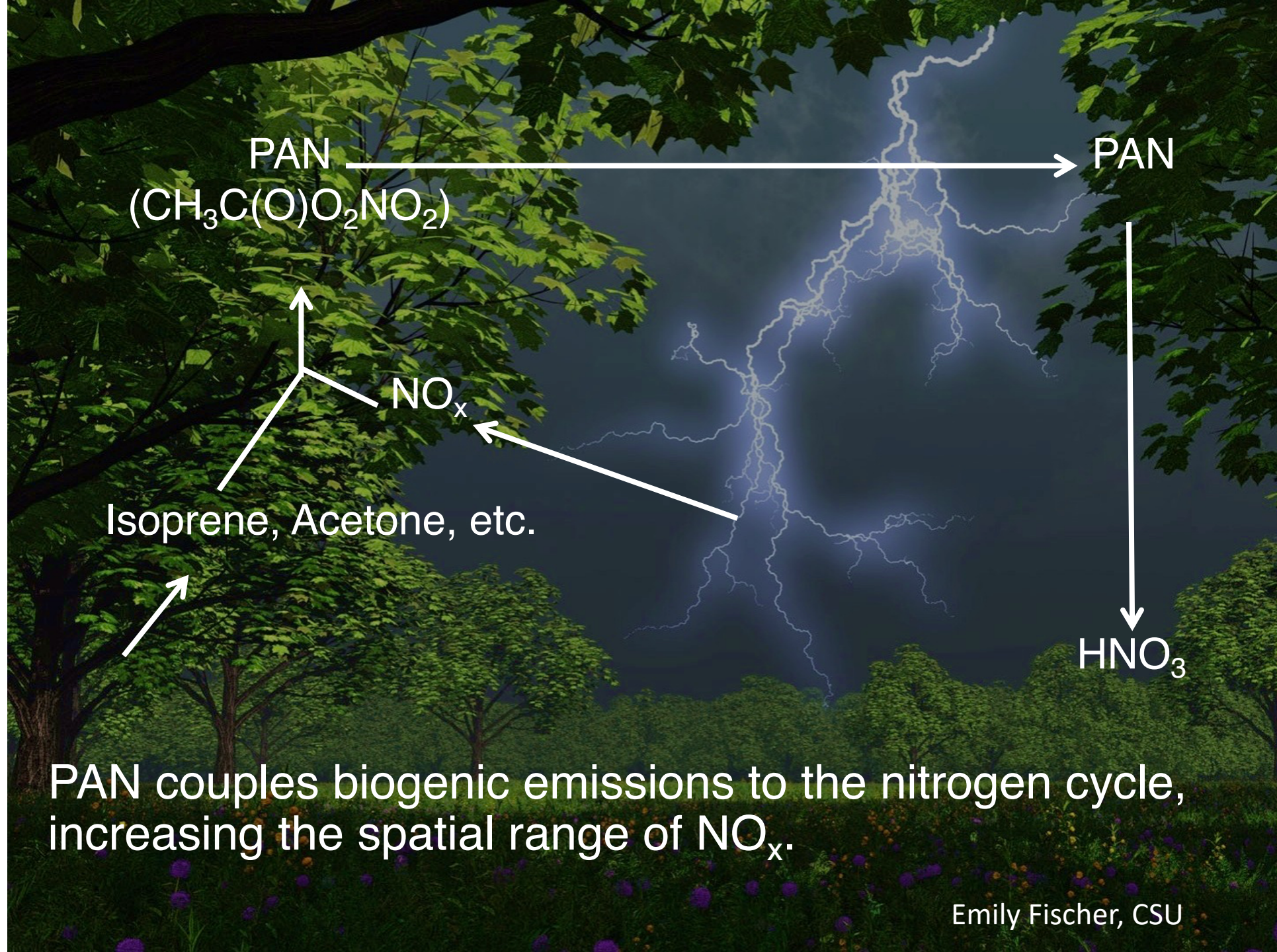Jet Propulsion Laboratory, California Institute of Technology

Co-Is:
Emily Fischer (Colorado State University), Susan Kulawik (BAERI/NASA Ames),
Dejian Fu (Jet Propulsion Laboratory, California Institute of Technology)

Collaborators:
Kevin Bowman (Jet Propulsion Laboratory, California Institute of Technology),
Greg Huey (Georgia Tech), Christopher Keller (NASA Goddard)

PAN is the route for NO$_x$ to reach the remote troposphere.

PAN
(CH$_3$C(O)O$_2$NO$_2$)

PAN

thermal decomposition

C$_x$H$_y$ NO$_x$ → HNO$_3$

NO$_x$ → HNO$_3$

O$_3$ and OH

NO$_x$ Source Region

Remote Atmosphere

PAN $\longrightarrow$ PAN
(CH$_3$C(O)O$_2$NO$_2$)

NO$_x$

Isoprene, Acetone, etc.

HNO$_3$

PAN couples biogenic emissions to the nitrogen cycle, increasing the spatial range of NO$_x$.

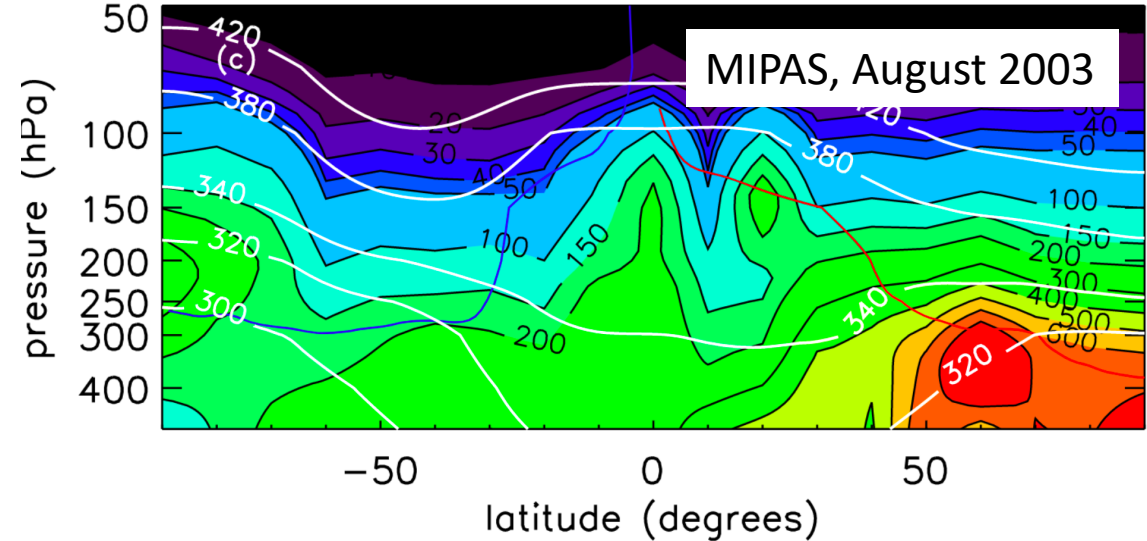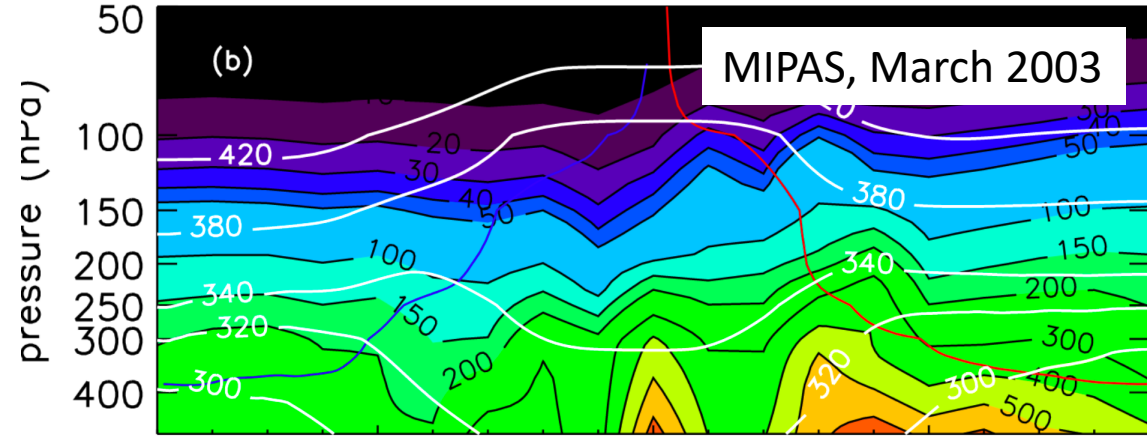PAN extends the air quality impacts of fires.
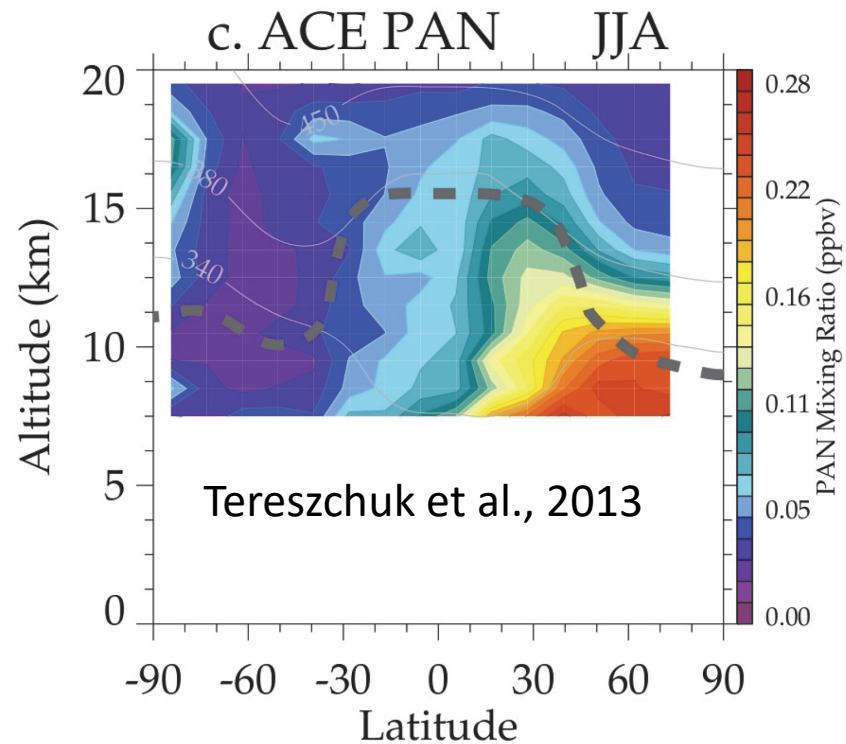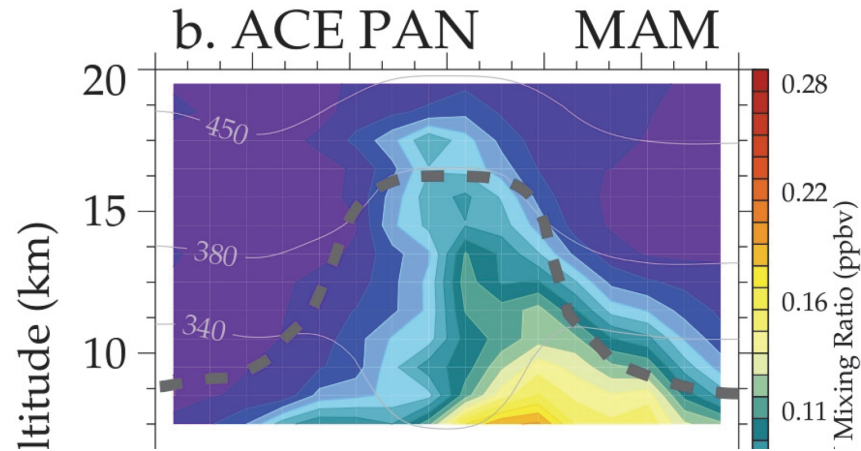
PAN

Emily Fischer, CSU

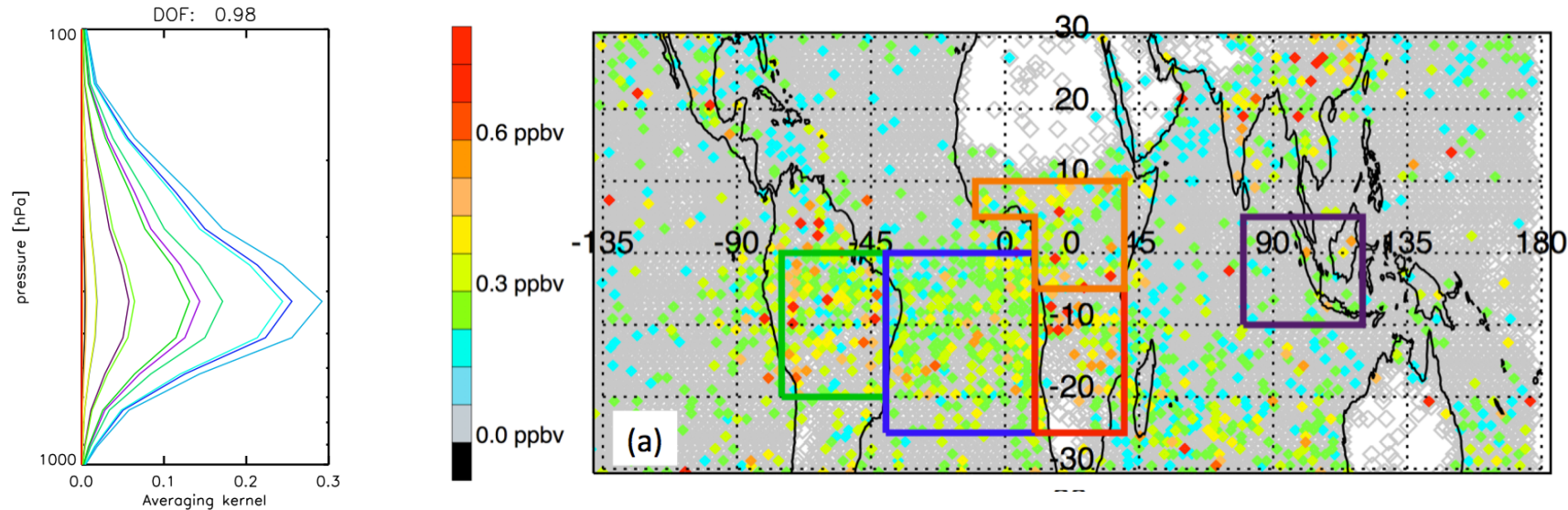Photos of High Park Fire from CNN

4

PAN: Expected Distribution
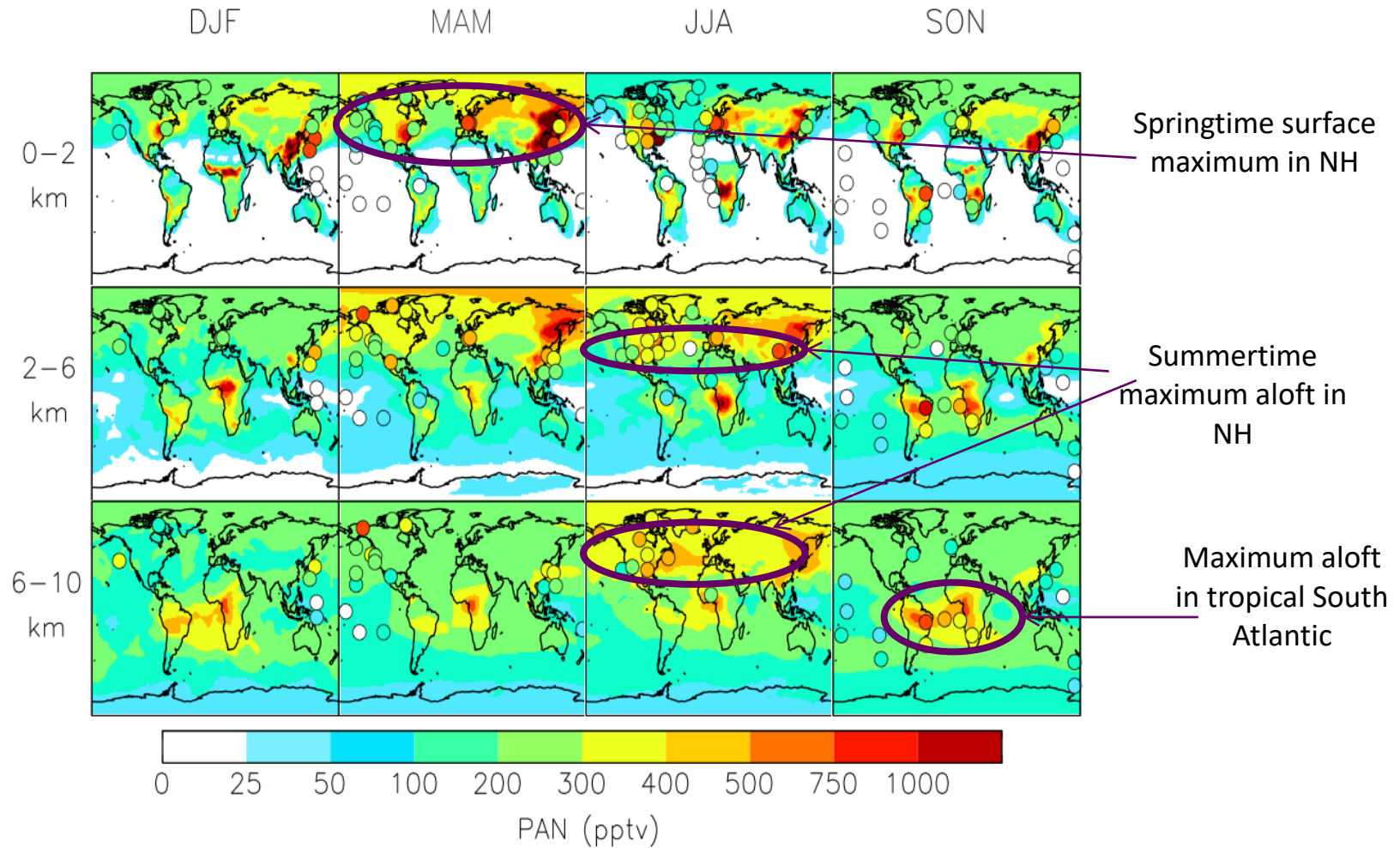
GEOS-Chem model with PAN scheme as described in **Fischer et al., 2014, ACP**

Satellite obs. of PAN: Limb sounders

b. ACE PAN   MAM

c. ACE PAN   JJA

Tereszchuk et al., 2013

MIPAS, March 2003

MIPAS, August 2003

Moore and Remedios, 2010

# Satellite obs. of PAN: Nadir sounders

- ## Nadir sounders
  - ### TES
    - Global PAN retrievals (optimal estimation) in v7 Level 2 product
  - ### IASI
    - Global PAN retrievals (neural net) presented by Franco et al. at EGU this year
  - ### CrIS

ROSES TASNPP project

- **"New constraints on the impacts of fires on air quality and the nitrogen cycle from CrIS observations of peroxyacetyl nitrate (PAN)"**
- Objectives:
  - Develop a new PAN data product from CrIS radiances.
    - **JPL MUSES algorithm (single footprint)**
  - Validate these new retrievals against independent measurements and compare to existing TES PAN measurements.
  - Use the new satellite PAN estimates to evaluate the ability of the GEOS-Chem model to represent the influence of North American summertime fires on photochemistry and reactive nitrogen.

Plans/processing priorities

- Algorithm development and initial testing.
  - **Comparisons with TES**
  - Retrievals over times/regions where aircraft data are available
    - **DC3**
    - **SEAC4RS**
    - **FRAPPE**
    - **KORUS-AQ**
    - **ATom**
    - **FIREX/FIREChem**
- Process data over North America for purposes of model evaluation
  - **August 2015:** Washington wildfires season was largest in state history
 - **August 2018:** WE-CAN aircraft campaign (Fischer is PI)

(a) CrIS spectrum

(b) CrIS PAN signal

(c) TES spectrum

(d) TES PAN signal
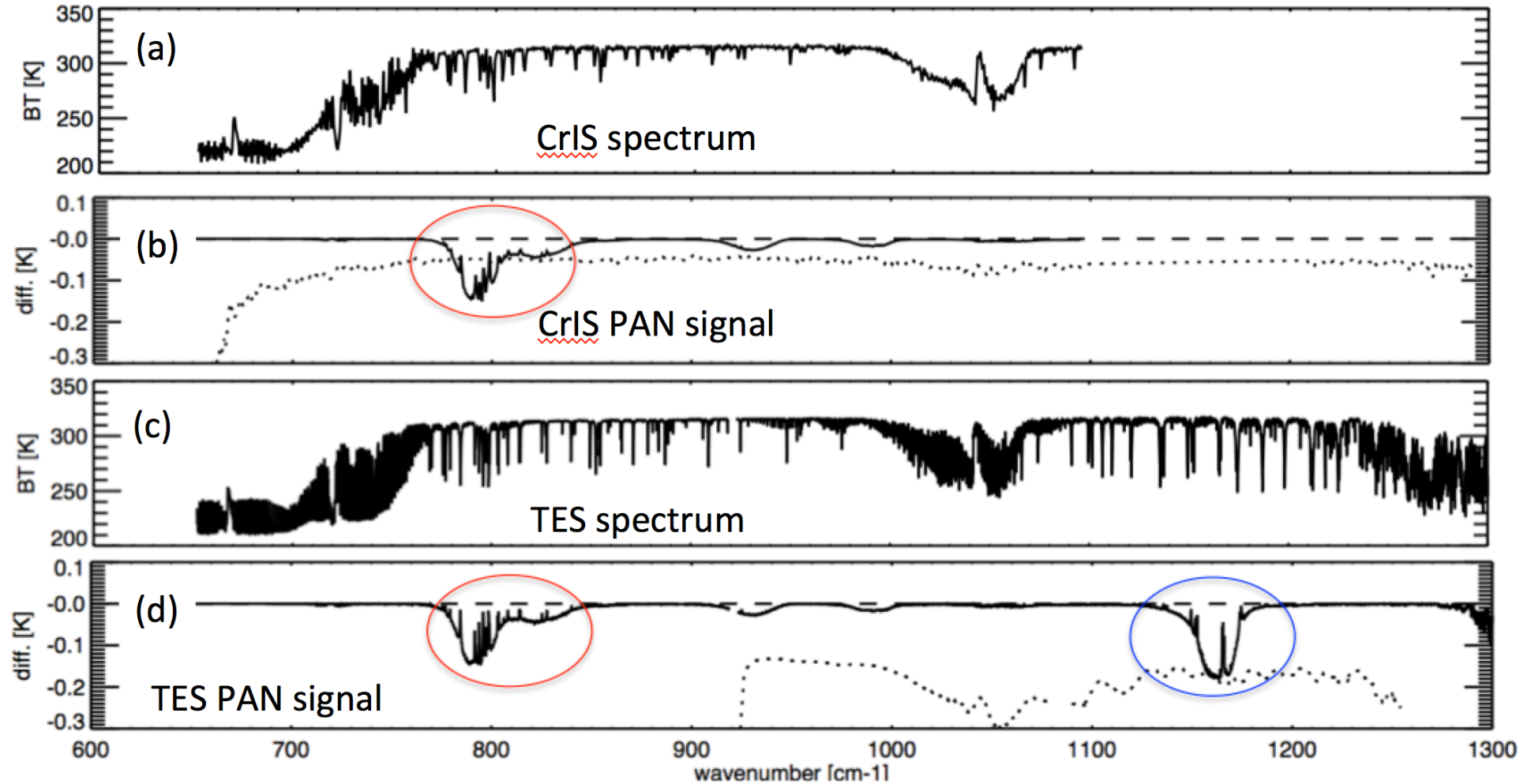
TES PAN retrievals are being processed routinely as part of the TES V7 Level 2 release.

Vertical sensitivity: TES and CrIS

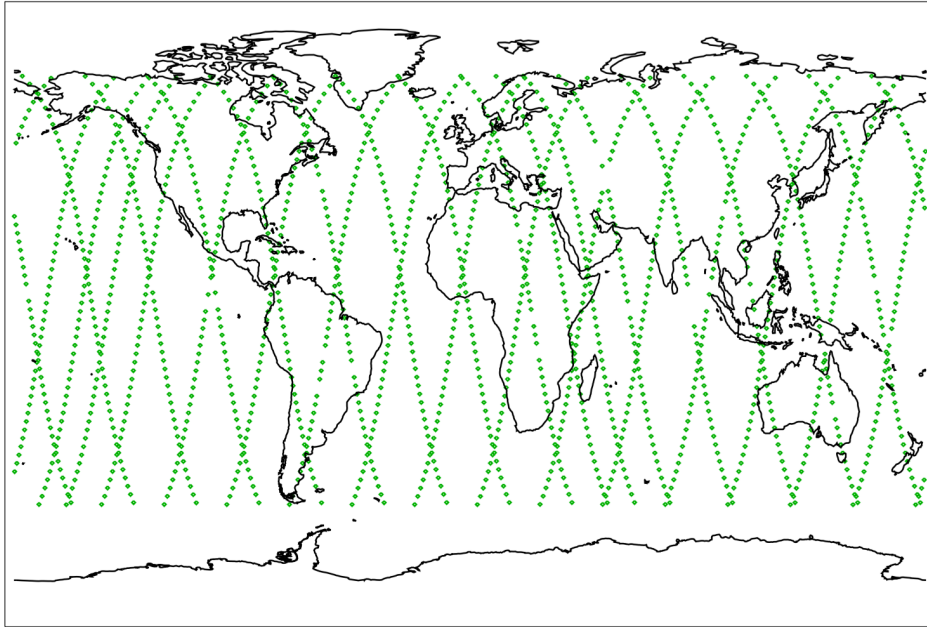Simulated retrievals using same true state
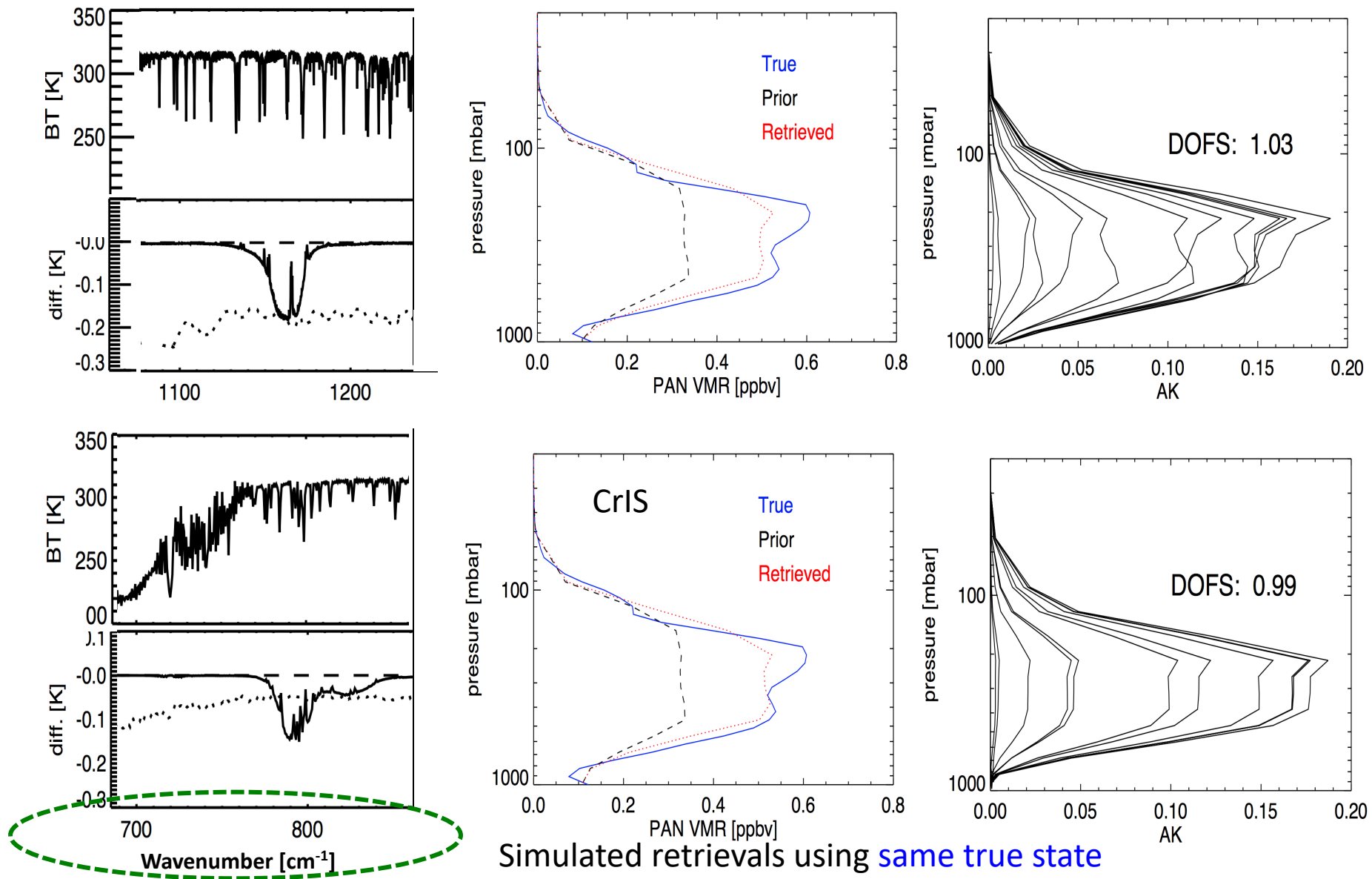
Temporal overlap of CrIS with TES

- TES:
  - Nominal mode of Global Surveys (GS): 2005-2011, 2017-2018
  - Observation strategy focused on special observations (SO): 2005-2018
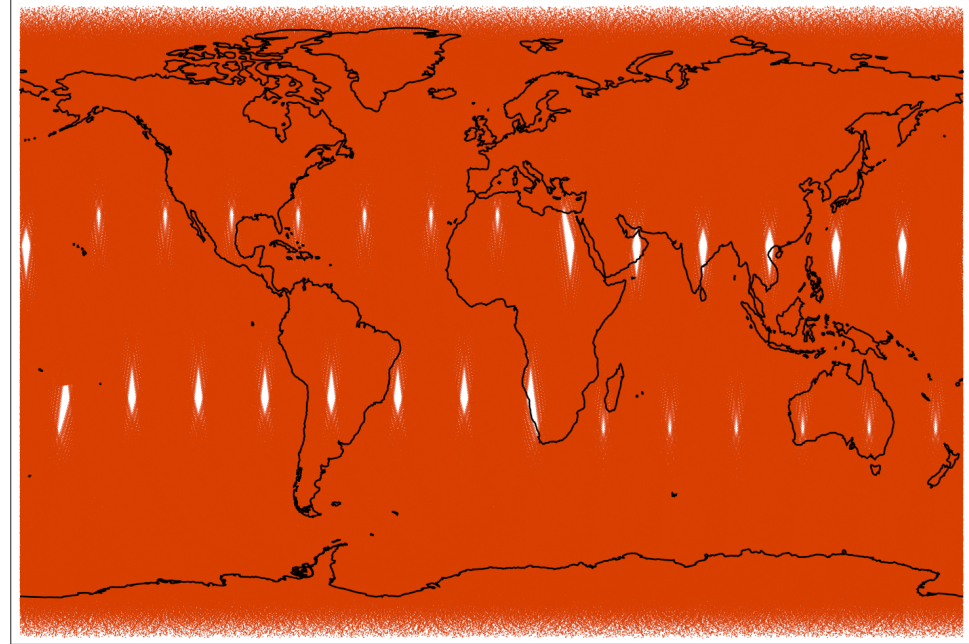 - Instrument decommissioned: January 2018
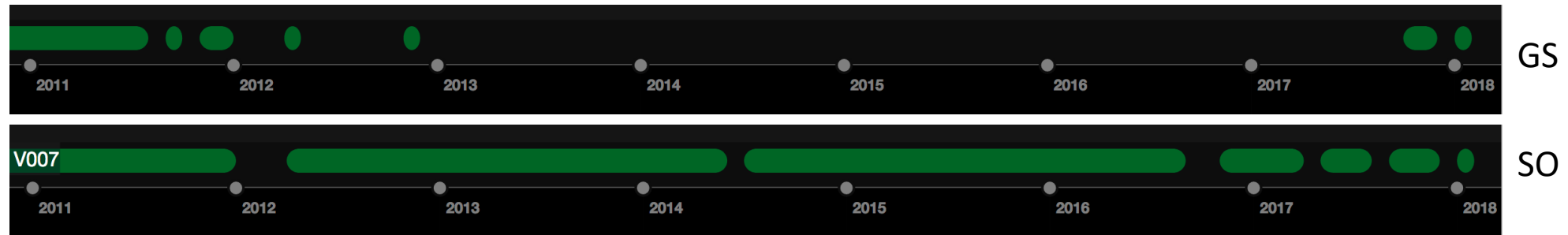
- S-NPP CrIS
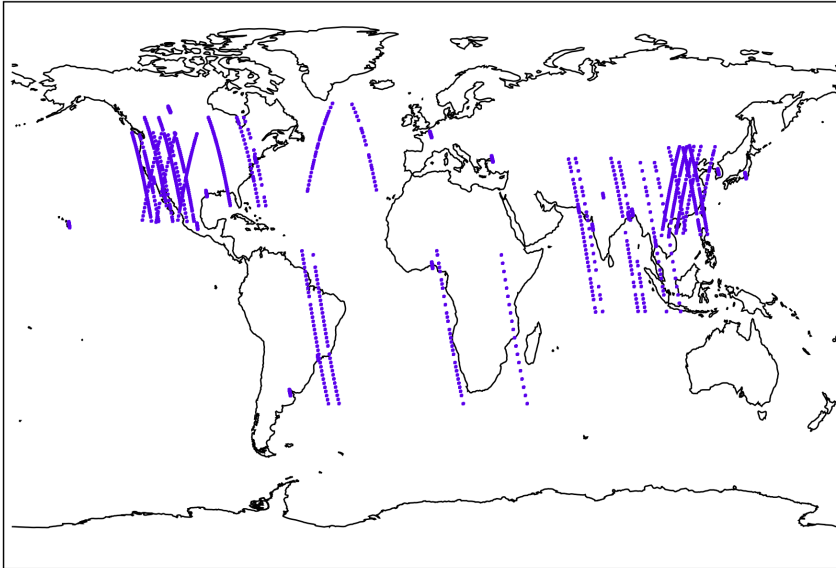 - launched October 2011

TES and CrIS coverage
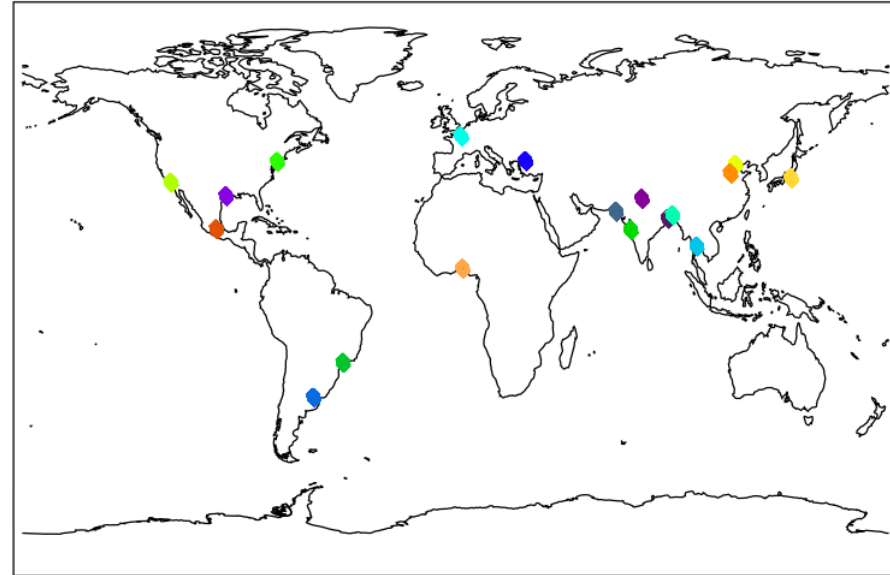

TES coverage for 8th November 2017

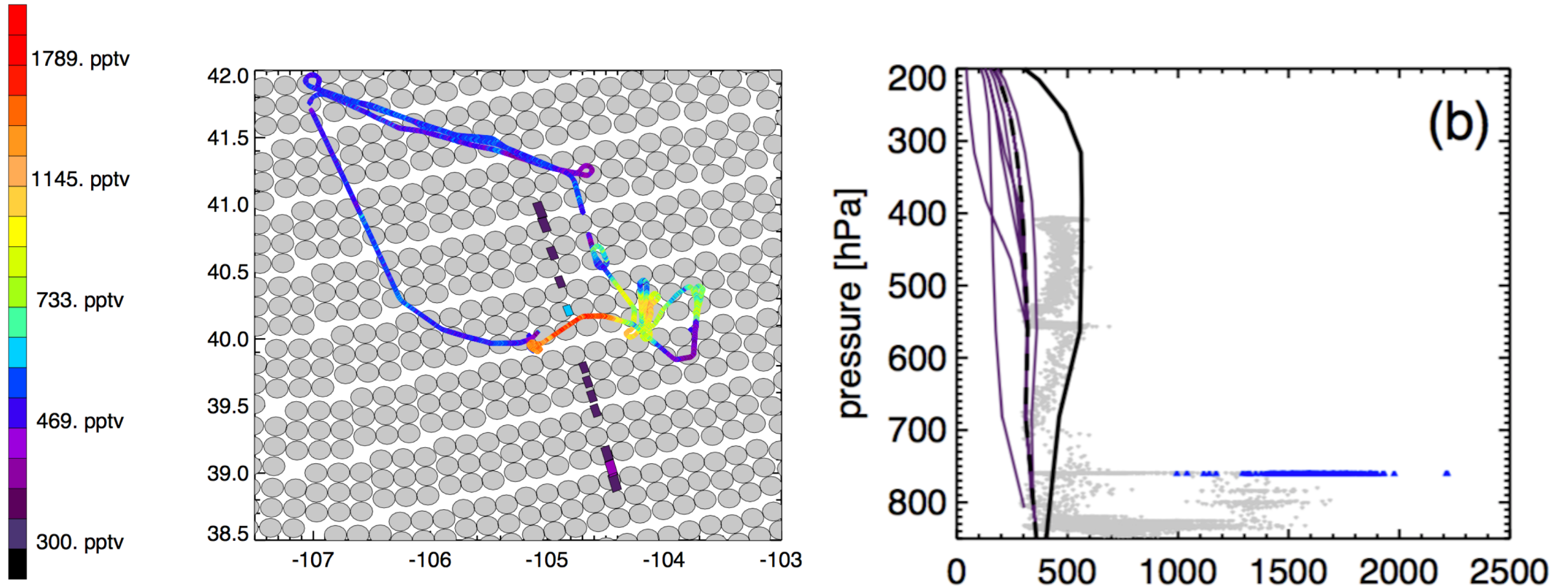SNPP-CrIS coverage for 8th November 2017

TES special observations

Example: TES observations August 2015

2013-2018 Megacity transect observations

Example from FRAPPE campaign (20140729)

Fischer et al., 2018. ACP

Validation opportunities: ATom
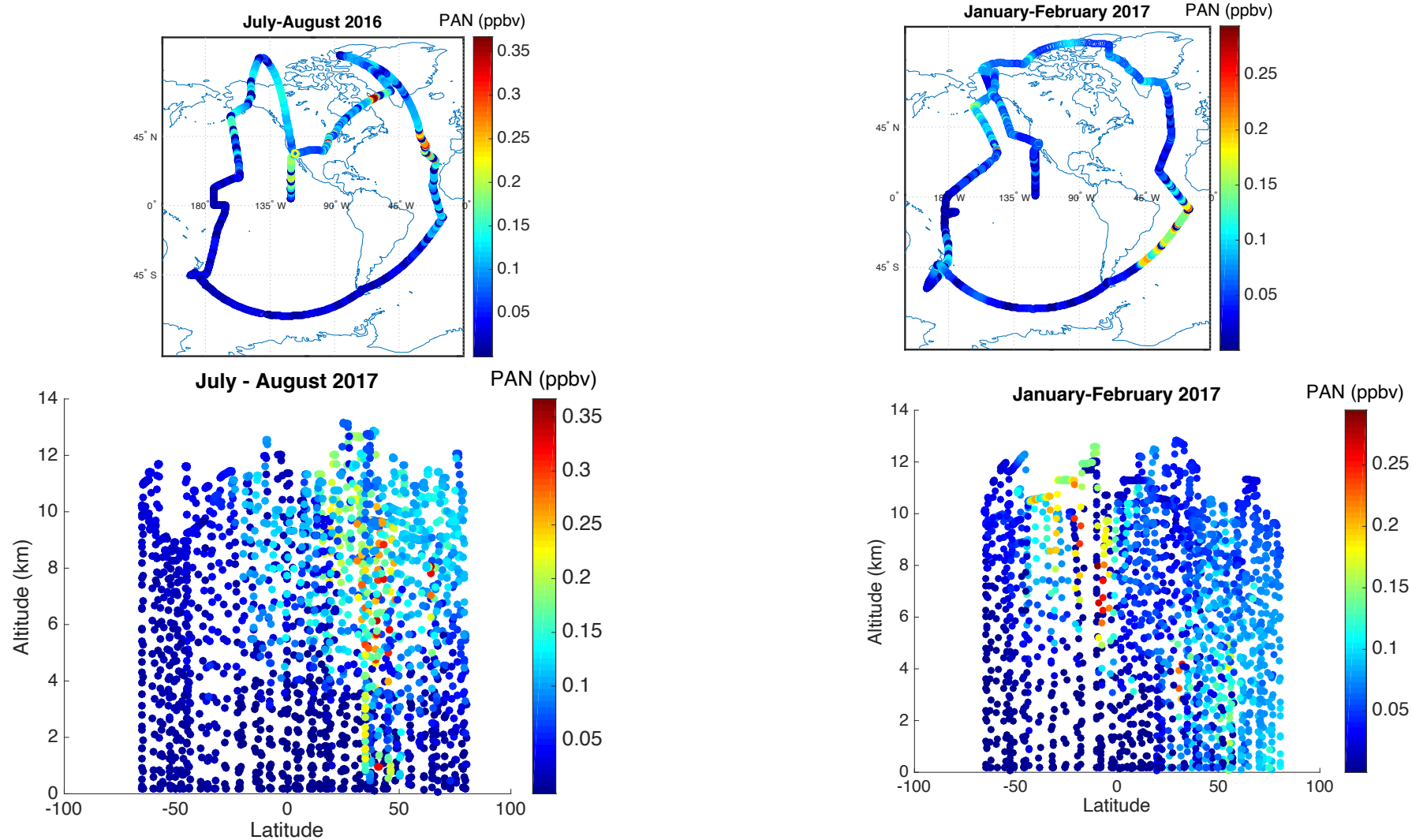
With thanks to Greg Huey (GT-CIMS PI)

Summary

- Peroxyacetyl nitrate (PAN) plays a critical role in:
  - Long-range pollution transport
  - Atmospheric chemistry
  - Redistribution of nitrogen in the troposphere

- CrIS PAN product will
  - Extend and enhance the existing record from Aura-TES
  - Provide new opportunities for validation
  - Provide new constraints on the representation of fires in the GEOS-Chem model

References

- **PAN from TES**
  - Alvarado et al., Atmosphere [2011]:
    - Emission Ratios for Ammonia and Formic Acid and Observations of Peroxy Acetyl Nitrate (PAN) and Ethylene in Biomass Burning Smoke as Seen by the Tropospheric Emission Spectrometer (TES)
  - Payne et al., AMT [2014]:
    - Satellite observations of peroxyacetyl nitrate from the Tropospheric Emission Spectrometer
  - Zhu et al., GRL [2015]:
    - TES observations of the interannual variability of PAN over Northern Eurasia and the Relationship to Springtime Fires
  - Jiang et al., JGR [2016]:
    - Ozone export from East Asia: The role of PAN
  - Zhu et al., JGR [2017]:
    - PAN in the eastern Pacific free troposphere: A satellite view of the sources, seasonality, internannual variability and timeline for trend detection
  - Payne et al., ACP [2017]:
    - Spatial variability in tropospheric peroxyacetyl nitrate in the tropics from infrared satellite observations in 2005 and 2006
  - Fischer et al., ACP [2018]
    - The Contribution of Fires to TES Observations of Free Tropospheric PAN over North America in July

References

- **PAN from satellite observations other than TES**
  - Moore and Remedios, ACP [2010]
  - Clarisse et al., JGR [2011]
  - Tereszchuk et al., ACP [2013]

Plans for processing

- Year 1:
  - Algorithm development and initial testing.
  - Process global maps of PAN for select days in order to assess overall consistency with TES
    - Probably use days in November 2017, when TES was taking global surveys
    - Downselect to ~50,000 obs
  - Process retrievals over times/regions where aircraft data are available
    - DC3 (~10,000 obs)
    - SEAC4RS (~6000 obs)
    - FRAPPE (~6000 obs)
    - KORUS-AQ (~10,000 obs)
    - Atom (3 deployments, ~30,000 obs each (~90,000 obs total)
- Year 2
  - Processing of small datasets at the TES Scientific Computing Facility for the purposes of GEOS-Chem model evaluation
  - Process data over North America for purposes of model evaluation
    - August 2015: Washington wildfires season was largest in state history, smoke blanketed much of western US (~50,000 obs)
    - August 2018: WE-CAN aircraft campaign (Fischer is PI) (~50,000 obs)
- Year 3
  - Implement and test algorithm on Sounder SIPS